NOAA Technical Report NESDIS 72

SUMMARY OF THE NOAA/NESDIS WORKSHOP ON DEVELOPMENT OF A GLOBAL SATELLITE/IN SITU ENVIRONMENTAL DATABASE

Washington, D.C.
August 1993

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

NOAA TECHNICAL REPORTS

National Environmental Satellite, Data, and Information Service

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NESDIS 15 NOAA N-ROSS/ERS-1 Environmental Data Development (NNEEDD) Products and Services. Franklin E. Kniskern, February 1985. (PB86 213527/AS)

NESDIS 16 Temporal and Spatial Analyses of Civil Marine Satellite Requirements. Nancy J. Hooper and John W. Sherman III, February 1985 (PB86 212123/AS)

NESDIS 18 Earth Observations and the Polar Platform. John H. McElroy and Stanley R. Schneider, January 1985. (PB85 177624/AS)

NESDIS 19 The Space Station Polar Platform: Intergrating Research and Operational Missions. John H. McElroy and Stanley R. Schneider, January 1985. (PB85 195279/AS)

NESDIS 20 An Atlas of High Altitude Aircraft Measured Radiance of White Sands, New Mexico, in the 450-1050 nm Band. Gilbert R. Smith, Robert H. Levin and John S. Knoll, April 1985. (PB85 204501/AS)

NESDIS 21 High Altitude Measured Radiance of White Sands, New Mexico, in the 400-2000nm Band Using a Filter Wedge Spectrometer. Gilbert R. Smith and Robert H. Levin, April 1985. (PB85 206084/AS)

NESDIS 22 The Space Station Polar Platform: NOAA Systems Considerations and Requirements. John H. McElroy and Stanley R. Schneider, June 1985. (PB86 6109246/AS)

NESDIS 23 The Use of TOMS Data in Evaluating and Improving the Total Ozone from TOVS Measurements. James H. Lienesch and Prabhat K. K. Pandey, July 1985. (PB86 108412/AS)

NESDIS 24 Satellite-Derived Moisture Profiles. Andrew Timchalk, April 1986. (PB86 232923/AS)

NESDIS 26 Monthly and Seasonal Mean Outgoing Longwave Radiation and Anomalies. Aronold Gruber, Marylin Varnadore, Phillip A. Arkin and Jay S. Winston, October 1987. (PB87 160545/AS)

NESDIS 27 Estimation of Broadband Planetary Albedo from Opertional Narrowband Satellite Measurements. James Wydick, April 1987. (PB88 107644/AS)

NESDIS 28 The AVHRR/HIRS Operational Method for Satellite Based Sea Surface Temperature Determination. Charles Walton, March 1987. (PB88 107594/AS)

NESDIS 29 The Complementary Roles of Microwave and Infrared Instruments in Atmospheric Soundings. Larry McMillin, February 1987. (PB87 184917/AS)

NESDIS 30 Planning for Future Generational Sensors and Other Priorities. James C. Fischer, June 1987. (PB87 220802/AS)

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SUMMARY OF THE NOAA/NESDIS WORKSHOP ON DEVELOPMENT OF A GLOBAL SATELLITE/IN SITU ENVIRONMENTAL DATABASE

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I. Introduction

A Workshop was convened September 9-11, 1992, at the NOAA Science Center, Camp Springs, Maryland, to discuss the development of a Global Satellite/In Situ Environmental Database (original workshop title "Comprehensive Satellite/In Situ Climate Data Product") that would address the requirements of the climate modeling and diagnostics communities. The objectives of the workshop included review of the current products of the National Environmental Satellite, Data, and Information Service (NESDIS) and development of recommendations and requirements for a combined satellite and surface (in situ) global climatology data set.

A group of approximately 35 individuals (Appendix I) that represented the operational satellite measurements, climate modeling, and climate diagnostic communities participated in the workshop.

The candidate data sets for inclusion in the Environmental Database included operational satellite products and, potentially, in situ data. Operational products discussed included Satellite Derived Atmospheric Soundings, Snow Cover, Sea Ice, Vegetation Index, Sea Surface Temperature, Ozone, Aerosols, and Planetary Radiation Budget data sets.

II. Product Summaries and Recommendations

Descriptions of the satellite-derived products discussed can be obtained from Kidwell (1991), NOAA (1991), or Ohring et al. (1989) (Appendix II). Each of the following products was reviewed by the participants and recommendations documented. The invited speakers that provided presentations on the products are listed after the product name.

i. Tiros Operational Vertical Sounder (TOVS): M. Goldberg

Data available currently include about 1.75 GB of data per year, for 13 years, in tabular point data format. The considerable variation that is possible in grid spacing, time composites, etc., may be a limitation for researchers interested in gridded data. There are currently few users of the data; however, the number may expand with better media and format.

Product Recommendations: The participants recommended that the data should be reformatted for better compression on storage media, yet must be convertible to the original format to fit existing ingest and processing software. These reformatted data should be transferred to Exabyte tape, with possible subsets of data on CD-ROM. Additional subsets could be made available over a network (this data should reside on a mass storage device).

One of the more climatologically significant products produced from TOVS is the Spencer and Christy (1990) product. This product was recommended for archive/distribution and adoption as a new operational product.

ii. Sea Surface Temperature (SST): W. Pichel

There exist several versions of SST; however, the Reynolds (1988) blended SSTs are preferred by many users (particularly in the atmospheric modeling community). Physical oceanographers, however, need higher temporal resolution for resolving oceanographic features such as eddies.

The U. of Miami's 18 km weekly gridded product (Smith, 1992) was cited as a useful product for oceanographic research.

Product Recommendations: Both of these data sets should be included in the Environmental Database. NOAA should investigate the accessibility of these data products. Distribution of the U. of Miami data product is encouraged.

iii. Snow Cover: J. Powers

A new weekly data product available from Rutgers University (Robinson, 1992) includes an improved land mask. A new monthly composite, that lists the percentage of a month with recorded snow cover, is also available.

Product Recommendations: The Rutgers University reprocessed data should be used in the Environmental Database.

iv. Sea Ice: F. Kniskern

The current NAVY/NOAA Joint Ice Center operational sea ice product was judged as the best such product available.

Product Recommendations: This product was recommended for inclusion in the Environmental Database.

v. Vegetation Index: D. Tarpley

The operational Global Vegetation Index (GVI) product has undergone several changes over its lifetime. Current deficiencies in the product (inherent to operational products) are the lack of application of post-launch calibration to the visible and near-IR data prior to computation of the normalized difference vegetation index (NDVI). Additionally, weekly composites of daily visible and near-IR data are based on maximizing the simple difference index, rather than the more commonly utilized NDVI.

Product Recommendations: A revised version of the GVI is currently under production at the University of Maryland and should be the best available product until the NOAA/NASA Pathfinder (Ohring and Dodge, 1993) data are available. This product, however, will not include any thermal-IR data. The Univ. of Maryland GVI have a spatial resolution of approximately 16 km at biweekly intervals.

The participants recommended that this data set should be included in the Environmental Database. Utilities for producing additional gridded versions of the data (e.g., convert from 16 km resolution to 0.5 or 1-degree grids) should be provided.

vi. Planetary Radiation Budget: H. Jacobowitz

These products have a serious problem due to orbital drift of the polar orbiting satellites. However, daily values make it a valuable set.

Product Recommendations: The data should be made available on CD-ROM or similar high density media. The Earth Radiation Budget Experiment data were also recognized as a valuable data set, however, these data are only available for a limited time.

vii. Ozone: W. Planet

Ozone data are available from TOVS and SBUV although deficiencies may exist. The SBUV data include total and column (vertical distribution) of ozone while only the total amount is available from TOVS. SBUV data are influenced by satellite orbital drift.

Product Recommendations: The current products were recommended for inclusion within the proposed Environmental Database. Both total amount and vertical distributions of ozone were recommended for inclusion.

viii. Aerosols: L. Stowe

Useful research data sets are available at several spatial and temporal resolutions.

Product Recommendations: These data were recommended for placement on convenient high-density media and included within the Environmental Database.

ix. In situ: M. Changery

The National Climatic Data Center has under preparation a compact disc that will include daily maximum and minimum temperature and precipitation for over 9,000 global weather stations. The disc will include data from 1975 through 1990.

Product Recommendations: The participants recommended that the global in situ surface and upper air data should be assembled with quality control applied.

Gridded global data from the National Meteorological Center's Global Data Assimilation System are available at a 2.5 degree resolution, but may be available in future at one degree resolution for surface values. The participants recommended that the individuals involved with the Environmental Database should be aware of this effort as the assimilated data may provide the best gridded surface and upper air data for potential inclusion with the satellite derived products.

III. General Recommendations

The participants agreed that limitations exist for the use of the operational products derived from the NOAA series of polar orbiting satellites for climate analysis and research. These limitations are due primarily to lack of post-launch calibration of visible and near-IR sensors and change in the equator crossing time of the satellite (satellite drift).

Discontinuities also exist in SST and some soundings products as algorithms utilized were occasionally changed to improve product accuracy. Documentation should be a high priority for all current data products. Algorithms that permit computation of changes in equatorial crossing times of NOAA Polar Orbiters should be included in documentation when applicable.

The participants recognized that several of the products originally produced by NOAA/NESDIS have been revised by individual investigators or research facilities (e.g., Global Vegetation Index and Snow Cover products) and recommended that NOAA pursue the acquisition of these revised products for archive and distribution. The participants also recommended that NOAA attempt to assure continued production of the revised products either within NOAA or by the investigators/facilities that initially produced them.

The participants agreed that more efficient storage media for the operational satellite products were needed as the current media limit usefulness due to high media volume and relatively high cost of data reproduction. All products currently archived on 9-track 1600 or 6250 bpi tapes were recommended for transfer to a more efficient and accessible storage device. Distribution of the products on Exabyte tapes was recommended. Further, the larger data sets available should be "packaged" and offered on media such as Exabyte or CD-ROM at a reduced price. No data selection (i.e., subset of data for specific time or space location) would be offered at this price.

The participants recommended that a time and space compatible data set that included either the current or, if available, revised products produced by NOAA would be useful to the research community. The Environmental Database should include those recommended products at a spatial resolution of 1 x 1° and a weekly temporal resolution. Products that are available at higher or degraded resolutions (e.g., 0.5 x 0.5° daily, or 2.5 x 2.5° monthly) were also recommended for inclusion in the Environmental Database. Gridding of the data from resolutions less than 0.5 x 0.5° (e.g., 16 km GVI product) would be based on recommendations of the NOAA Product Oversight Panels. Generally, the resolutions of data included in the Environmental Database should be a multiple of the base (1°) resolution for compatibility of data. The Environmental Database should, for ease of use, be an equal-angle product.

Documentation of algorithms used to produce all products included in the Environmental Database was defined as a high priority by the participants. References and a flow chart for production of each product were recommended for inclusion with the Environmental Database. The documentation should be comprehensible to current and potential users of the data.

The reformatting/conversion of the individual data sets may be appropriate tasks for the NOAA Data Centers. The completion of this task would be a significant contribution by the Data Centers to climate and global change research.

NOAA should attempt to assure continuity of data products and establish an online bulletin board to inform the research community of product revisions. A prototype bulletin board, initiated by the National Geophysical Data Center (NGDC), exists on SCIENCEnet (Omnet) as GLOBAL.DATA.

The NOAA/NGDC Global Change Database (NOAA, 1992) (and its Global Ecosystems Database) were cited as examples upon which the Global Satellite/In Situ Environmental Database could be modeled.

IV. Recommendations for Pathfinder Data Interuse

The participants were requested to provide recommendations for compatible products derived from the Pathfinder data sets. The NOAA/NASA Pathfinder effort was recognized as a mechanism to provide the research community with products that will be generally superior to the currently available (operational or revised) products. The participants of this Workshop recommend that NOAA consider adoption of the processing algorithms used for the Pathfinder products for the production of a new set of NOAA operational products. This effort would result in the availability of future consistent and improved products that would be readily comparable to the Pathfinder products as they become available.

Discussions related to the interuse of Pathfinder data sets resulted in recommendations that AVHRR land and ocean products be degraded to .5 x .5 or 1 x 1° and that atmosphere products remain 1 x 1°. GOES products were recommended for .5 or 1° as were SSMI.

V. Acknowledgments

This workshop was supported with funds provided by NOAA's Earth System Data and Information Management program.

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Appendix II. Ohring et al., (reprint)

Ohring, G., K. Gallo, A. Gruber, W. Planet, L. Stowe, J.D. Tarpley, 1989: Climate and Global Change: Characteristics of NOAA Satellite Data. Eos, 70, 889,891,894,901.

Eos, Vol. 70, No. 41, October 10, 1989, Pages 889,891,894,901

Climate and Global Change

Characteristics of NOAA Satellite Data

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The principal finding of an International Council of Scientific Unions (ICSU)/Committee on Space Research (COSPAR) ad hoc group on Remote Sensing for Global Change [*Rasool*, 1987] was that "The current international operational satellite system, augmented with the technology developed by research missions and supported by validation experiments and a comprehensive data system, could provide the basis for a global change observing system." The National Oceanic and Atmospheric Administration's environmental satellites represent a significant part of the international system.

NOAA manages a NOAA series of polar orbiters and a Geostationary Operational Environmental Satellite (GOES) series of geostationary satellites. A NOAA satellite can view each point on the Earth's surface every 12 hours, at approximately the same local time each overpass. An attempt is made to maintain two NOAA satellites in orbit at all times, a so-called afternoon "bird" with nominal observing times of 2 P.M. and 2 A.M. and a morning bird with observations at 7 A.M. and 7 P.M. A GOES satellite hovering over the equator views continuously the surface of the Earth within 60° Earth central angle of the subsatellite point. NOAA operates a two-GOES system, one nominally stationed at 75°W and the other at 135°W.

Although designed primarily for weather observations, these satellite measurements contain considerable information on climate parameters. While much remains to be done to raise the quality of satellite observations to the levels required by many global change problems—mainly through improved calibration and validation procedures—the existing archives represent a rich source of data for attacking a number of such questions.

It is the purpose of this article to describe the characteristics of available NOAA satellite data sets and provide information on how to obtain data. Because of their mix of instruments and products, and their global coverage, the NOAA polar orbiter series will be emphasized.

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Radiance Data

Tables 1 and 2 summarize key orbital and payload characteristics of the NOAA and GOES satellites, respectively. The basic observations of each instrument are radiances at particular wavelengths. These observations are archived at the lowest level of processing that has scientific utility. The data are saved at the highest resolution available from the spacecraft, as well as in some sampled and averaged forms.

Observations from the Advanced Very High Resolution Radiometer (AVHRR), the TIROS Operational Vertical Sounder (TOVS), and the Solar Backscatter Ultra-Violet (SBUV) instrument are saved in the Level 1b format. The 1b data consist of raw data that have been quality controlled and to which Earth location and calibration data have been appended but not applied. Ancillary data such as time codes, solar zenith angle, satellite scan angle, and some quality indicators are also included. The data reside in the archive in sets consisting of data from a particular instrument for a single orbit or a subset of an orbit.

The AVHRR data are saved in two forms, Local Area Coverage (LAC) and Global Area Coverage (GAC). The GAC data, with a resolution of 4 km × 1 km and one sample for every 15 km^2, are available globally twice each day from each polar orbiter. The LAC data are taken at 1 km × 1 km resolution and are available from only about 10% of each orbit. Coverage with LAC data is determined by user request.

The TOVS data are archived separately for each component sensor. The sensors are the High Resolution InfraRed Sounder (HIRS), the Microwave Sounding Unit (MSU), and the Stratospheric Sounding Unit (SSU). The sounder data are available globally twice each day from each spacecraft.

The primary instrument on the GOES is the Visible Infrared Spin Scan Radiometer (VISSR), which is operated in an imaging mode and an atmospheric sounding mode (VISSR Atmospheric Sounder or VAS). The VISSR uses the spinning of the spacecraft and a stepping telescope to make images of the Earth's disk as seen from geostationary orbit. The configuration of the GOES prevents the VISSR from being operated in the VISSR imaging mode and the VAS mode at the same time. The normal operating procedure is for full disk images to be made at half-hourly intervals with VAS data taken only at certain times which may vary depending on weather conditions.

The data are archived digitally in sectors which may include the full disk or subsets of it. The data are in the form of calibrated counts which can be converted to geophysical units by means of a fixed look-up table. The VISSR data are supplied from the archive in digital arrays with navigation information appended, and a given (or specified by the requestor) center latitude and longitude. Software is also supplied that uses the navigation data to calculate the latitude and longitude of any pixel in the array.

Further details on instrument characteristics and the archived data can be found in the

Cover. The image of the 1987 AVHRR Vegetation Index Annual Normalized Difference Days was prepared as part of a research effort to examine the use of remotely sensed data to monitor global vegetation as a potential tool for monitoring global climatic conditions. The annual Normalized Difference (ND) days represent the seasonal duration of green vegetation for a given location. Regions of the world with long growing seasons, e.g., equatorial rain forests, display the greatest annual number of ND days. The annual number of ND days generally decreases, as the length of the growing season decreases, with increased latitude north or south of the equator. Fluctuations in this general trend are primarily due to terrain (mountains) or major climatic features (deserts).

The image was produced at the U.S. Geological Survey/NMD EROS Data Center, Sioux Falls, S.Dak., from the weekly NOAA/NESDIS Vegetation Index (GVI) product. More than 650 megabytes of data were processed to produce the image. The weekly GVI data have been processed to compute the Normalized Difference Vegetation Index from calibrated data of bands 1 and 2 of the NOAA AVHRR. Additional processing removed cloud contaminated data, data drops due to instrument or data relay problems, and data acquired at solar elevation angles less than 15°. Weekly data were composited biweekly to further reduce cloud contamination. Biweekly values of the normalized difference vegetation index, greater than a base value of 0.1, were weighted by the number of days in the sample interval (14) and cumulated over a year to provide the annual ND days. Computation of annual ND days for 1986 and 1988 is in process.

Image courtesy of Kevin P. Gallo, NOAA/NESDIS, EROS Data Center, Sioux Falls, S.Dak., and Jesslyn F. Brown, TGS Technology, Inc., EROS Data Center, currently at the Geography Department, University of Nebraska-Lincoln.

See "Climate and Global Change: Characteristics of NOAA Satellite Data," by G. Ohring et al., this issue.

TABLE 1. NOAA-Advanced TIROS-N (ATN) Weather Satellites

Sensor	Applications	Number of Channels/ Frequencies	Spectral Range/ Frequency Range	Resolution	Swath Width
AVHRR/2 (Advanced Very High Resolution Radiometer)	Cloud Temperature, Sea Surface Temperature, Land Temperature, Vegetation Index	5	0.58–12.5 μm	1.1 km	2700 km
HIRS/2 (High-Resolution Infrared Sounder)	Temperature and Moisture Profiles	20	3.8–15.0 μm	17.4 km	2240 km
SSU (Stratospheric Sounding Unit)	Atmospheric Sounding, Temperature Profiles	3	14.7 μm (Centered)	147 km	736 km
MSU (Microwave Sounding Unit)	Atmospheric Sounding	4	50.3–57.05 GHz	109 km	2347 km
SBUV* (Solar Backscatter UV Experiment)	Solar Spectrum, Ozone Profiles, Earth Radiance Spectrum	12	252.0–339.8 nm	169.3 km	Nadir Viewing

*P.M. satellite only.

Objectives of mission: meteorological observations, measurements of sea surface temperature, sea ice, and snow cover, assessment of condition of vegetation; orbit characteristics: polar, 833–870 km altitude, 7 A.M. and 2 P.M. equator crossing times.

TABLE 2. Geostationary Operational Environmental Satellite (GOES)

Sensor	Applications	Number of Channels/ Frequencies	Spectral Range/ Frequency Range	Resolution	Swath Width
VAS (Visible and Infrared Spin Scan Radiometer	Imaging–Day/Night Cloud Cover	5	0.55–0.7 μm 3.90–14.7 μm	1 km—Vis 8 km—IR	Limb to limb
[VISSR] Atmospheric Sounder)	Sounding—Temperature and Water Content	12	3.90–14.7 μm	14 km	Limb to limb

Objectives of mission: operational weather data, cloud cover, temperature profiles, real-time storm monitoring, severe storm warning, sea surface temperature; orbit characteristics: geostationary at east and west longitudes.

NOAA Polar Orbiter Data User's Guide [*Kidwell*, 1986] and the *GOES Data User's Guide* [*Gibson*, 1984], both available from the Satellite Data Services Division (SDSD), NOAA/NESDIS, Room 100, Princeton Executive Center, Washington, DC 20233; tel. 301-763-8399, which serves as the archive for most of the satellite data discussed in this article.

Products

The observed radiances are transformed to meteorological and geophysical variables by means of processing algorithms of varying complexity.

Sounding Products

TOVS data are available since 1979 [*Smith et al.*, 1979]. For clear instrumental fields of view, or those containing partial cloudiness, the temperature and moisture profiles, and ozone amounts are retrieved from clear column radiances derived from the observations. For total cloudiness conditions, only the temperature profile is retrievable—from the microwave observations. Information on clouds is also obtained. A physical retrieval system has recently been implemented.

Validation of the satellite soundings against radiosonde observations indicates rms temperature differences of 1°-2°C and total precipitable water differences of 30% of the precipitable water. Similarly, a comparison of the TOVS ozone with Dobson observations shows differences of 15-20 Dobson units. The cloud product has not been validated.

The sounding products are archived as temperature profiles from the surface to 0.4 mbar; precipitable water for three atmospheric layers (surface-700, 700-500, and 500-300 mbar); tropopause pressure and temperature; cloud amount and height; and total ozone amount estimates. Nominal resolution for these products is 250 km, and data can be ordered from NOAA/NESDIS/SDSD.

Sea Surface Temperature (SST)

Since the launch of TIROS-N in the fall of 1979, NOAA has been deriving global SSTs from the AVHRR. The SSTs are obtained twice daily (day and night) using the two visible and the three infrared channels to select clear fields of view and then using the infrared channels to correct for atmospheric water vapor absorption [*McClain et al.*, 1985]. Matchups of satellite and drifting buoy observations indicate random differences of about 0.6°C and systematic differences within ±0.3°C. The global day and night data are archived as instantaneous values at a nominal 8-km resolution, a composite weekly analysis on a 1° latitude/longitude grid, and as monthly means for 2.5° latitude/longitude bins. Data may be obtained from NOAA/NESDIS/SDSD.

Snow Cover

Since November 1966, NOAA has produced a weekly northern hemisphere snow map [*Matson et al.*, 1986]. The snow maps are produced using visible imagery from the AVHRR and VISSR instruments. The snow charts are made using photointerpretative techniques from the most recent cloud-free images obtained during the week. The weekly snow charts are manually digitized on a subset of a 128 × 128 polar stereographic map. The resolution of the mapped snow charts is 190 km at 60°N.

The snow maps are archived on a weekly and monthly basis. All data since the northern hemisphere 1966-1967 snow season are on a single tape that is updated monthly. From these data the total area covered by snow each month is calculated for the northern hemisphere, North America, and Eurasia. An *Atlas of the Satellite-Derived Northern Hemispheric Snow Cover Frequency* is available from NOAA/NESDIS Office of Research and Applications, and a description of the archived snow cover data is available from NOAA/NESDIS/SDSD.

Sea Ice

Since January 1972 for the Arctic, and since January 1973 for the Antarctic, the U.S. Navy/NOAA Joint Ice Center (JIC) has been producing weekly sea ice charts. Relying to a large extent on an analyst's interpretation of satellite images, the JIC derives sea ice extent, ice concentration, and ice thickness. The primary sources for these analyses have been the AVHRR visible and infrared images supplemented by NASA's Nimbus-5 Electronically Scanning Microwave Radiometer (ESMR) and Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR), the Defense Meteorological Satellite Program's (DMSP) visible and microwave (Special Sensor Microwave/Imager, SSMI) observations, and in situ observations. The weekly charts are digitized and gridded at a spacing no greater than 15 nm on an evenly divisible latitude/longitude geographic grid. The sea ice data are available from the National Snow and Ice Data Center, National Geophysical Data Center, NOAA, Boulder, CO 80303. NOAA's Climate Analysis Center maintains time series of the spatially integrated sea ice data.

Vegetation Index

The vegetation index product of NOAA [*Tarpley et al.*, 1984] has provided a once-per-week view of nearly the entire Earth since May 1982. The vegetation index is a measure of the vigor and density of green vegetation and is derived from daily data acquired by the AVHRR with local orbit times in the early afternoon. A weekly composite is produced that utilizes daily visible and near-IR data to screen the data of each map cell such that the "greenest" or most "cloud-free" data of each week is retained for each map cell. Thermal-IR data in two wavebands, as well as information on the solar zenith and satellite scan angles associated with the AVHRR data of each map cell, are included with the visible and near-IR data in each weekly composite. The normalized difference vegetation index (NDVI)

NDVI = (near-IR - visible) / (near-IR + visible)

is computed for each map cell, based on the composited visible and near-IR data and is included in the weekly product. In addition to the availability of weekly composite data since May 1982, daily data similar to that described for the weekly composites are available since April 1985. The weekly and daily data are available in several map projections that have slightly different formats and spatial resolutions. Further information is contained in the *Global Vegetation Index User's Guide*, available from NOAA/NESDIS/SDSD.

Planetary Radiation Budget

Since 1974, the planetary albedo and outgoing longwave radiation (OLR) have been estimated from the window channel measurements of the imaging radiometers on the polar orbiters. Table 3 summarizes the satellites used, their lengths of record, and the spectral intervals of the radiometers.

Until May 1988, the planetary albedo was estimated by assuming that the visible channel reflectance is equal to the broadband reflectance and that the reflected energy is isotropic. Since May 1988, a linear combination of the AVHRR visible and near-infrared radiances has been used to obtain a broadband radiance, followed by the application of angular models to obtain the reflected flux [*Wydick et al.*, 1987, *Taylor et al.*, 1987].

TABLE 3. Characteristics of Satellites Used in Obtaining Planetary Radiation Budget

Satellite	Equator Crossing	Spectral* Intervals Used, μm: Visible	Spectral* Intervals Used, μm: Infrared	Period of Record
NOAA SR	0900–2100	0.55–0.70	10.5–12.5	June 1974–Feb. 1978
TIROS-N	0330–1530	0.55–0.90	10.5–11.5	Jan. 1979–Jan. 1980
NOAA-6	0730–1930	0.58–0.68	10.5–11.5	Feb. 1980–July 1981
NOAA-7	0730–1939	0.58–0.68	11.5–12.5	Sept. 1981–Jan. 1985
NOAA-9	0230–1430	0.58–0.68 0.725–1.0**	11.5–12.5	Feb. 1985–Oct. 1988
NOAA-10	0730–1930	0.58–0.68	11.5–12.5	March 1988–present
NOAA-11	0130–1330	0.58–0.68 0.725–1.0	11.5–12.5	Nov. 1988–present

*50% response points.
**Included as of May 1988.

The OLR is obtained from the infrared window channel measurements by a regression equation that relates the limb-corrected brightness temperature to an equivalent broadband flux temperature, from which the outgoing flux is determined. The algorithm has changed somewhat over time, but stability of the entire record has been maintained by recalculating earlier OLR values [*Gruber and Krueger*, 1984].

A one-month comparison of the NOAA OLR values with coincident Earth Radiation Budget Experiment (ERBE) measurements [*Yang et al.*, 1988] showed that the rms difference was 5.5 W/m^2 and that the global mean NOAA OLR was 3 W/m^2 less than that of ERBE.

The data are archived as daily values and monthly means in two formats: a 125 × 125 grid-per-hemisphere (spatial resolution varies from about 100 km at the equator to about 200 km near the poles) and a 2.5° × 2.5° latitude/longitude grid. Quantities archived include daily values of both day and night OLR, absorbed solar radiation, and available solar radiation. These data sets are available from NOAA/NESDIS/SDSD.

Ozone

Since the launch of NOAA-9 at the end of 1984, the afternoon polar orbiters have carried SBUV instruments for ozone determinations. This continues the series of ozone measurements begun by the SBUV instrument on NASA's Nimbus-7 satellite, launched at the end of 1978. These instruments measure the spectrum of solar ultraviolet radiation scattered back to space by the Earth's atmosphere, which depends on how much of the radiation is absorbed by the Earth's ozone layer. Inversion of the observed spectrum yields information on the total amount and vertical distribution of the ozone.

The ozone data products are under technical evaluation by a NOAA/NASA science team. Results thus far indicate that the NOAA-9 SBUV/2 total ozone amounts are diverging from those measured by the ground-based Dobson spectrophotometer network and the Nimbus-7 SBUV at a rate of about 0.7% per year. The reasons for this drift are unknown at present. Therefore users are cautioned not to use the data, at this time, for long-term trend determinations within the error limits cited above. Short-term changes and the general ozone patterns from NOAA-9 agree very well with the other ozone observations. Therefore these data are very well suited for examining short time scale features of ozone variability, as well as the general synoptic structure.

SBUV/2 information is archived on tape in four modes: The *1b Data Set* contains SBUV/2 sensor data and support data necessary for the derivation of atmospheric ozone and solar flux; instrument inflight calibration data and housekeeping functions for monitoring postlaunch instrument changes; and prelaunch calibration factors, and computed current-day instrument calibration and albedo correction factors to adjust the ozone algorithm for actual instrument performance.

The SBUV/2 sensor data consist of radiance and irradiance measurements taken in both the discrete mode (12 wavelengths) and the sweep mode (1680 wavelengths) at approximately 2-a intervals. The support data include Earth location data, cloud and temperature data, ancillary data to initialize the algorithm, surface pressure data, and snow ice data.

The *Historical Instrument File* (HIF) contains the data necessary to characterize the instrument performance and albedo correction over time. Included are diffuser degradation, preliminary irradiances, i.e., before application of albedo correction factors, electronic calibration data and wavelength calibration data.

The *Product Master File* (PMF) tape contains information that is derived from the 1b data set. This includes but is not limited to ozone amounts, calibration constants, interim products used to derive ozone amounts, solar positions, and certain quality control parameters.

The *Product User File* (PUF) contains a subset of the information on the PMF. This includes the final ozone amounts, solar zenith angles, and Earth location for each sounding.

The archived ozone data—except for the vertical profile data, which are still undergoing validation—may be ordered from NOAA/NESDIS/SDSD. Detailed information on SBUV/2 may be found in the *User's Guide* [*Oslik*, 1984], available from NOAA/NESDIS/SDSD.

Aerosols

Visible radiance measurements in channel 1 (0.58–0.68 μm) of the AVHRR on board the polar orbiters are being used to determine the optical thickness (OT) of aerosol particles in the total atmospheric column (proportional to the total number of particles in the atmosphere) over oceans. The aerosol OT is determined by matching the measured radiances with computed radiances from realistic models of cloud-free, plane-parallel atmospheres with different aerosol OTs, and finding the model OT which provides the best match [*Griggs*, 1983].

Validation with Sun-photometer measurements indicate that the satellite estimates of OT are accurate to ±0.05. Quality control measures to detect the presence of clouds within the field of view of the radiometer and to reject cloud-contaminated data from global analyses have been developed and implemented in the aerosol retrieval algorithm [*Rao et al.*, 1988]. Objective analysis of the satellite-derived aerosol OT has been employed to generate a 100-km grid, contour-analyzed aerosol field over the global oceans on a weekly basis.

Weekly contour charts and digital tapes of the individual aerosol OT observations are available from June 1987. Since July 1989, monthly mean charts and digital tapes of the analyzed weekly and monthly fields are available. These products can be obtained from the NOAA/NESDIS/National Climatic Data Center, Attention: Product Code No. AER2, Federal Building, Asheville, NC 28801.

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